

Performance and Results from the Globe at Night – Sky Brightness Monitoring Network

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Light Pollution: Theory, Modelling and Measurements conference

29.6.2017

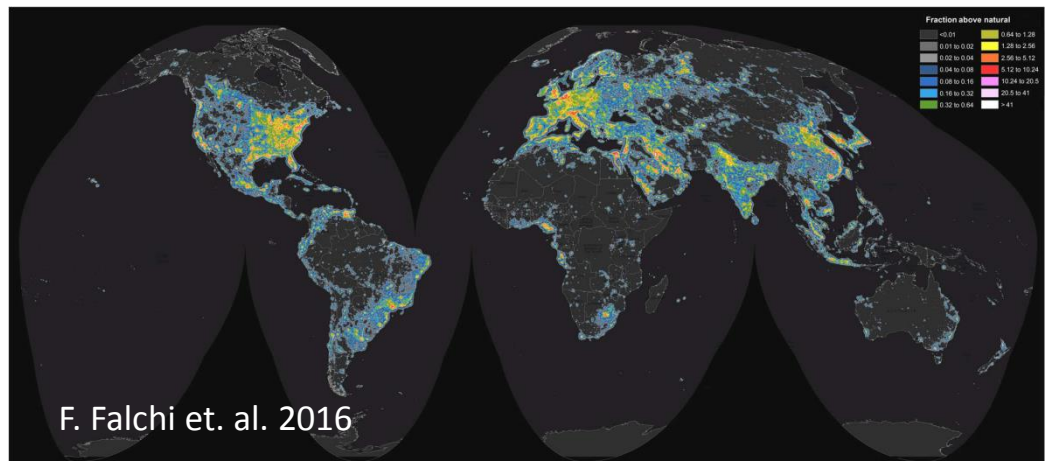
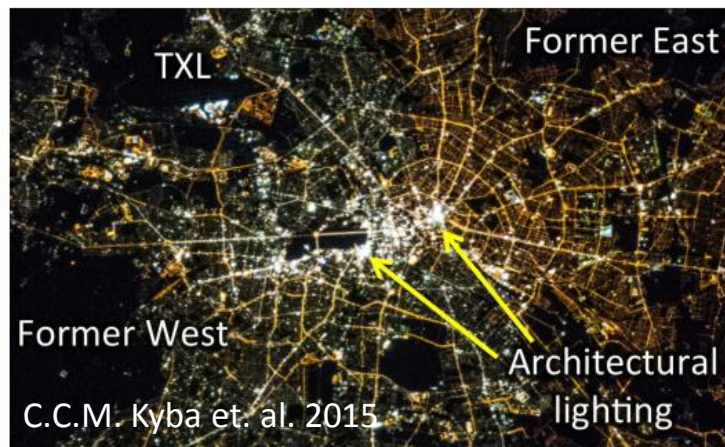
Supported by the HKU Knowledge Exchange fund

Challenge

**To measure the extent of light
pollution over large area**

1. Measuring Light Up ↑

- **Remote sensing** (DMSP-OLS, VIIRS-DNB, ISS, etc)
 - Upwelling light emitted directly from the light sources and light reflected off the Earth's surface.
 - Challenging calibration issues but can be overcome
 - Large spatial coverage (city → regional → global)
 - Low temporal sampling (each location normally has one chance of overpass within an evening; DMSP: 19:30, VIIRS: 01:30)



2. Measuring skyglow $\uparrow\downarrow$

- **Limiting magnitude** (e.g. Globe at Night, since 2006)
 - Citizen science project to report conditions of the night sky
 - Large geographical (115 countries) & temporal coverages with low cost
 - Uncertain data quality within the data set (± 1.2 mag, due to various observing experience & mistakes made during data reporting, Kyba 2013)

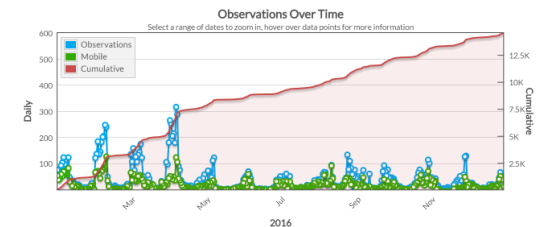


In 2016, Globe at Night received

14,611 Observations

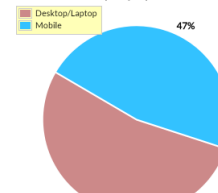
from **97** Countries

& **52** US states

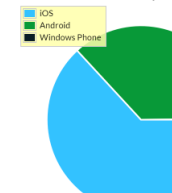


Data is submitted via mobile devices, as well as desktop & laptop computers

Desktop/Laptop vs. Mobile



Mobile by OS



Mobile by Device/App

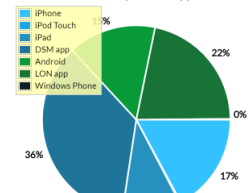


Image credit: Globe at Night

2. Measuring skyglow ↑↓

- **Measuring Night Sky Brightness (NSB)**
 - Through mobile phone apps or specialized light sensing meters
 - Mobile phone citizen science (e.g. Dark Sky Meter): good geographical but unsteady temporal coverage
 - Dedicated measuring devices: for SQM, limited temporal and geographical coverage
 - With ethernet or data-logger versions of SQM, we can set high sampling rate also good temporal coverage
 - **Temporal coverage provides a direct linkage with the pattern of light usage.**

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Endorsed by the IAU Executive Committee Working Group for the **International Year of Light 2015** as a major Cosmic Light program
- Co-organizers:
 - Office of Astronomy Outreach, International Astronomy Union (IAU)
 - National Astronomical Observatory of Japan
 - The University of Hong Kong
 - The Globe at Night project



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Project aims:
 - **Standardized** night sky measurement method for worldwide research on light pollution
 - Highlight the negative **environmental impacts** of abusive artificial lighting for the general public and **policy makers**
 - Sustain light pollution **public education** and promote **public engagement** by live worldwide night sky brightness data and night sky measuring programs

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Methodology and highlights:
 - Zenith night sky brightness observation
 - Standardized observing method:
 - SQM-LE
 - Reasonable cost and sturdy
 - Standard Unihedron housing
 - reduce inconsistency in optical window attenuation
 - 30 seconds sampling interval
 - Standardized calibration scheme



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- GaN-MN currently (June 2017) has:
 - **23** stations operating in **9** countries/regions in **3** continents
 - Over **30** million individual measurements had been collected

The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Current stations (23 in total):

Germany 1
Hungary 2

Mongolia 1

South Africa 1





Macau 3

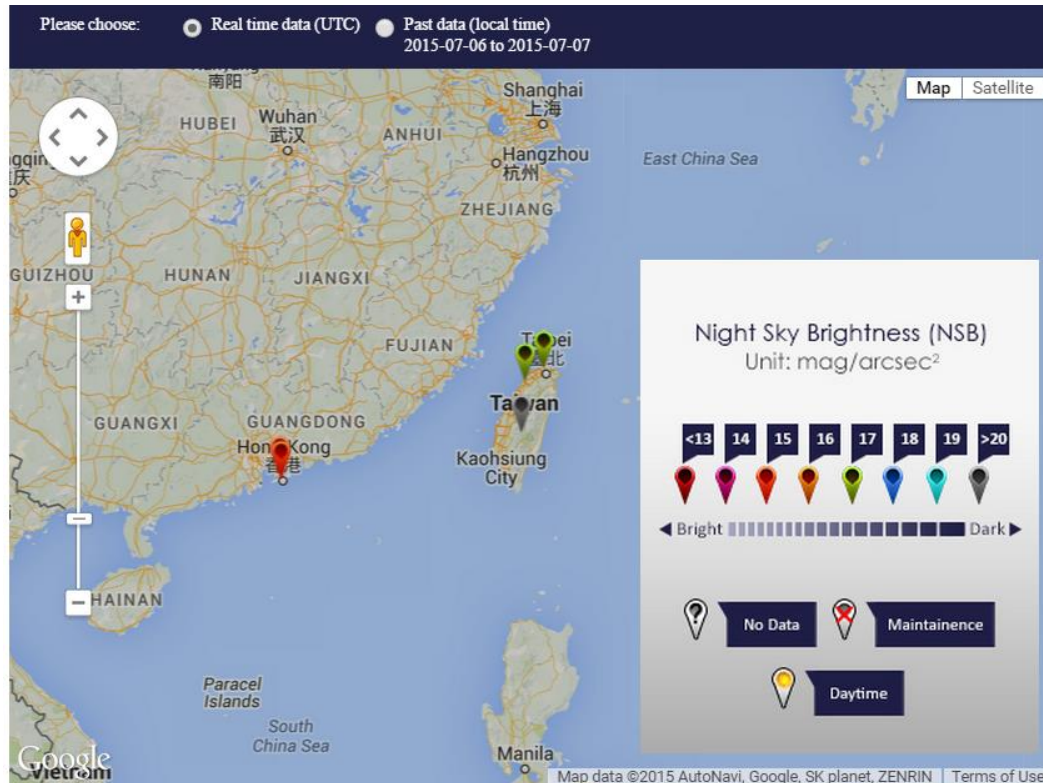
Hong Kong 2



Data sharing:

1. Public interface of GaN-MN (embedded in Google map)

<http://globeatnight-network.org/>



- Location currently at night: instantaneous real-time data
- Location currently during day-time: median value of NSB taken during previous night

Data sharing:

2. Real-time database

- All NSB data collected from GaN-MN stations fed to a MySQL database automatically and instantaneously
- Full sharing of real-time data from all stations among participating stations
- Participants access database through a user-friendly web-based interface
- Database allows for studies of temporal and geographical variations of light pollution and their correlations with various natural and artificial factors

Data sharing:

3. Archival database (accessed through *Globe at Night* page)

<https://www.globeatnight.org/gan-mn.php>

(Home page > Maps & Data)



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Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

The [GaN-MN](#) project, an extension of the original *Globe at Night* project, is a global night sky brightness monitoring network using a commercially available meter ([SQM-LE by Unihedron](#)) for long-term monitoring of the light pollution conditions in different places around the world.

The project aims to:

1. deploy a standardized night sky measurement method for worldwide light pollution research;
2. highlight the negative environmental impacts of abusive artificial lighting for the general public and policy makers; and
3. sustain light pollution public education and promote public engagement by live worldwide night sky brightness data and night sky measuring programs.

About the GaN-MN Data

Globe at Night is hosting data taken by this network. It can be downloaded as a CSV file that can be opened in any spreadsheet application. The file has the following headers:

id: unique ID for each data entry
created: timestamp according to the server clock
received_utc: timestamp converted to UTC
received_adjusted: timestamp corrected to local time
sqmle_serial_number: serial number of SQM-LE
nsb, sensor_frequency, sensor_period_count, sensor_period_second, temperature: raw data reported by the unit, where nsb: reading in magnitudes per square arc second, see section 8.6 of [the manual](#)
device_code: code of monitoring station (location of SQM-LE), [complete list](#)

Download the GaN-MN Data

2017	2016	2015	2014
<ul style="list-style-type: none">• Jan_2017 (163.4 MB)• Feb_2017 (127.0 MB)	<ul style="list-style-type: none">• Jan_2016 (92.1 MB)• Feb_2016 (81.5 MB)• Mar_2016 (91.5 MB)• Apr_2016 (93.1 MB)• May_2016 (95.9 MB)• Jun_2016 (110.4 MB)• Jul_2016 (128.0 MB)• Aug_2016 (142.2 MB)• Sep_2016 (144.1 MB)• Oct_2016 (155.0 MB)• Nov_2016 (144.0 MB)• Dec_2016 (157.4 MB)	<ul style="list-style-type: none">• Jan_2015 (18.5 MB)• Feb_2015 (31.0 MB)• Mar_2015 (38.8 MB)• Apr_2015 (40.6 MB)• May_2015 (34.8 MB)• Jun_2015 (37.1 MB)• Jul_2015 (37.2 MB)• Aug_2015 (70.0 MB)• Sep_2015 (87.3 MB)• Oct_2015 (85.5 MB)• Nov_2015 (86.0 MB)• Dec_2015 (92.0 MB)	<ul style="list-style-type: none">• Nov_2014 (2.9 MB)• Dec_2014 (9.0 MB)

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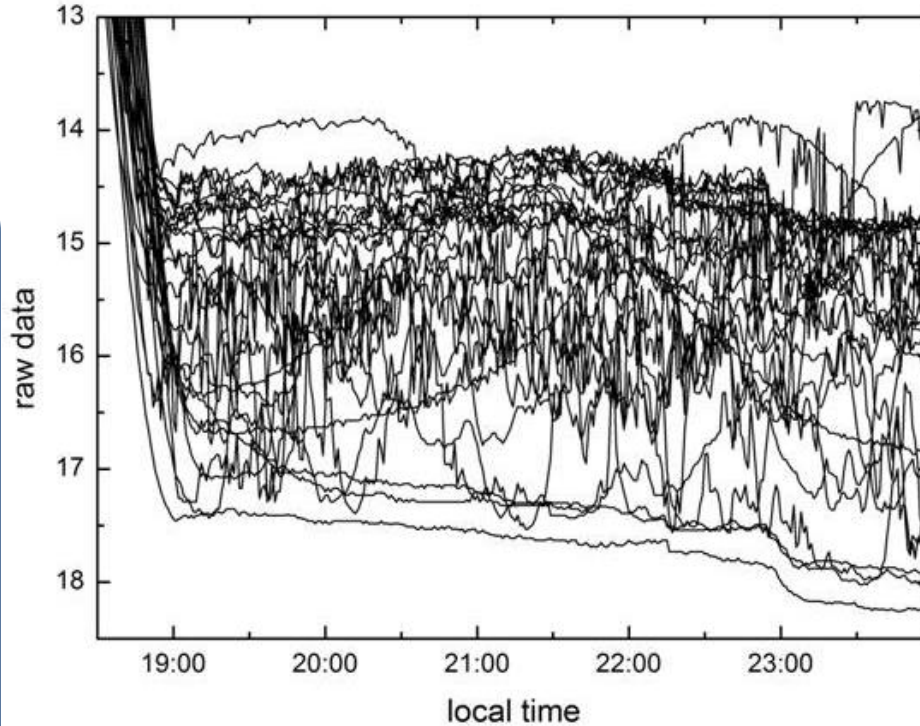
- New archival file around once per month
- Raw data only limited quality check. Please contact us for details.

Raw data taken over one month at one station between 18:30 – 00:00

Astronomical



Galaxy, starlight,
moonlight,
sunlight, etc



Meteorological / Atmospheric



Cloud, rain, air
pollution, etc

Anthropological

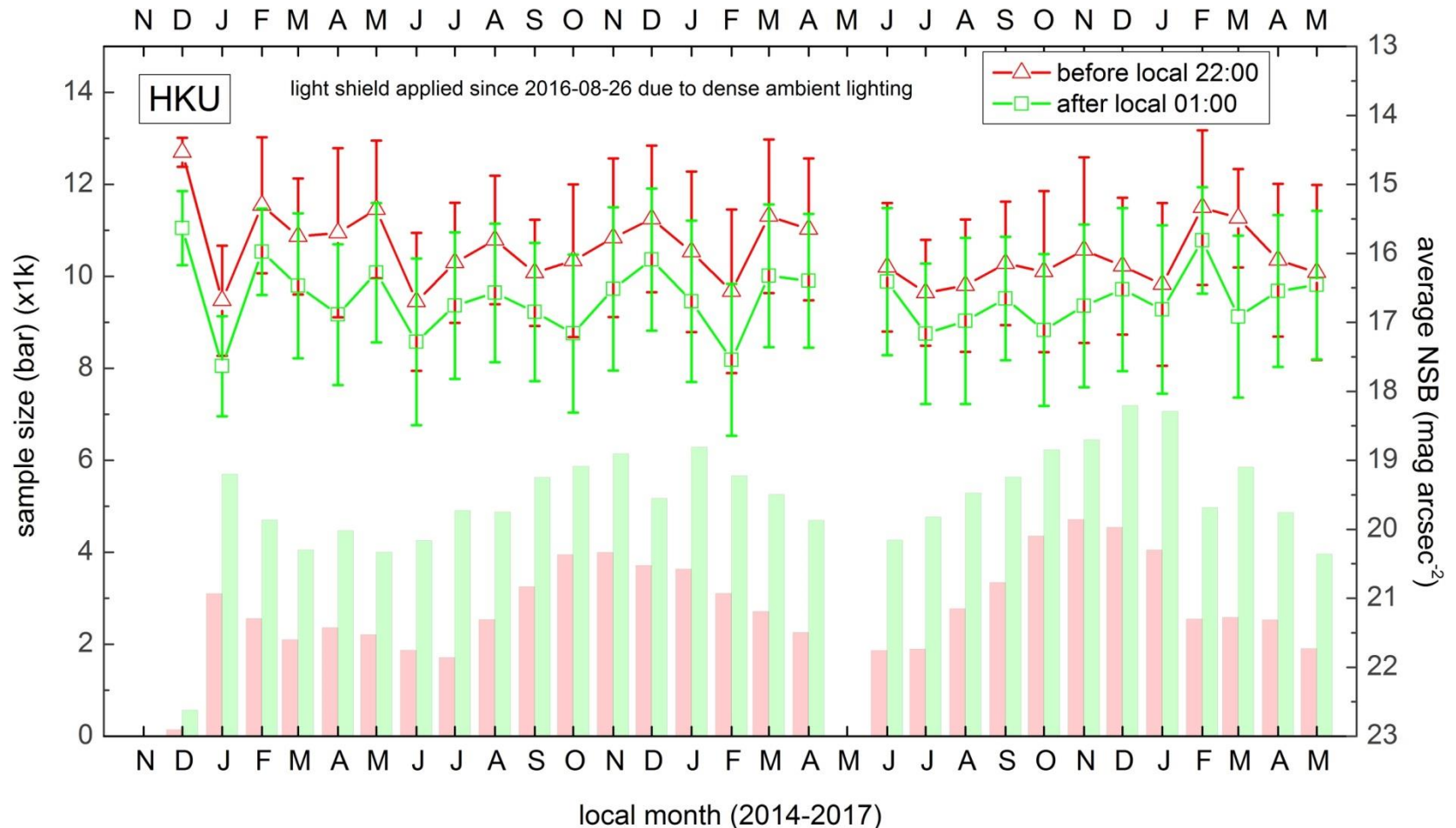


Public and private
lighting, different
colors, different
angles, LED, etc

Data Selection

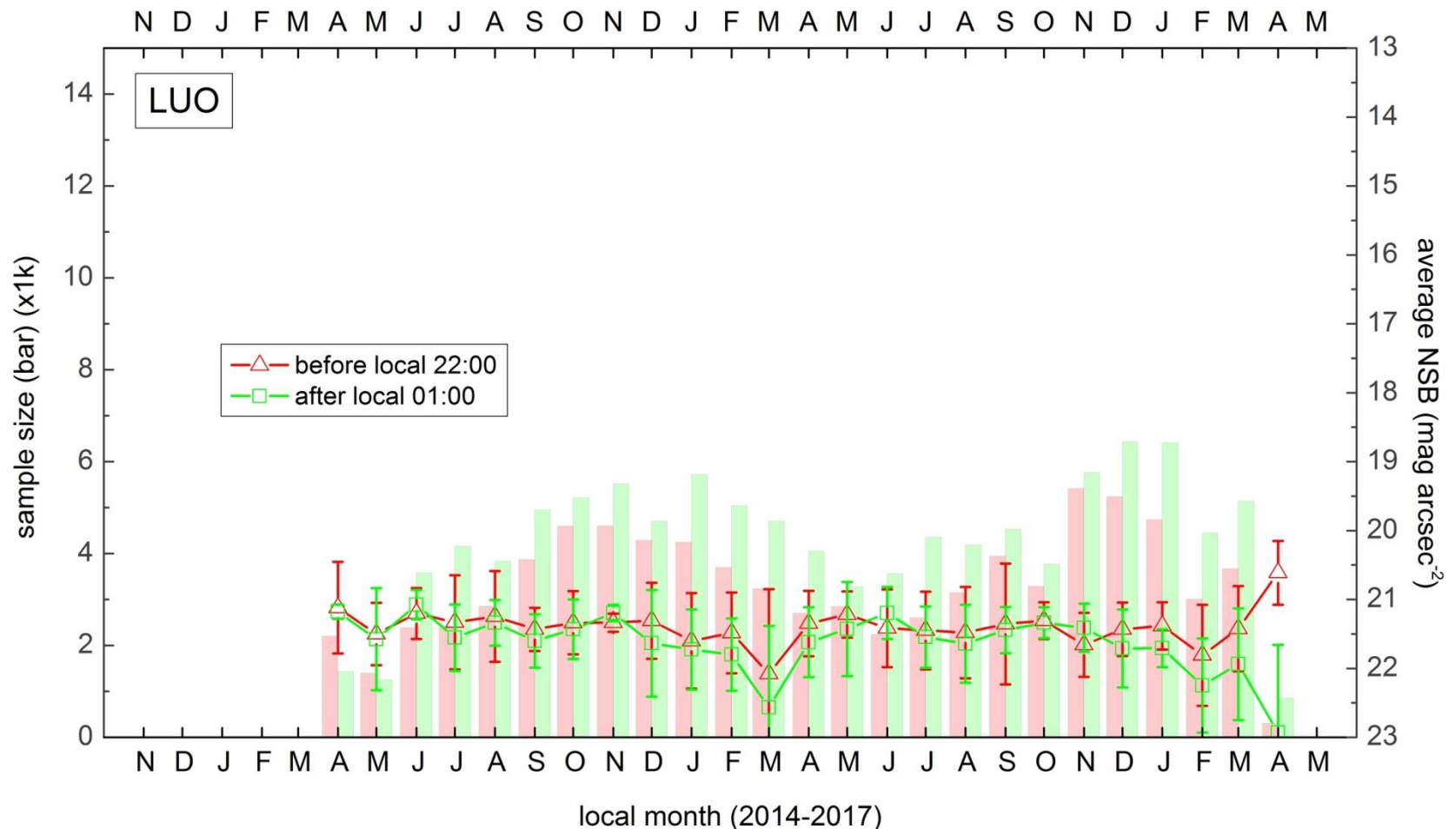
- For this particular analysis, focus on how and how much artificial lighting can affect the observed NSB (**urban skyglow**)
- Data excluded due to:
 - Sun (twilight)
 - Moon
 - artificial activities (such as observatory functions, etc)
- Data NOT excluded:
 - star/planetary light, Milky Way galaxy
 - rain
 - cloud

Monthly sample size (bars) and average NSB (lines) of a GaN-MN **urban** station (Hong Kong)



- ✓ Early evening brighter than late evening (lighting usage)
- ✓ Seasonal fluctuations (variations of cloud amount)

Monthly sample size (bars) and average NSB (lines) of a GaN-MN **rural** station (central mountain Taiwan)



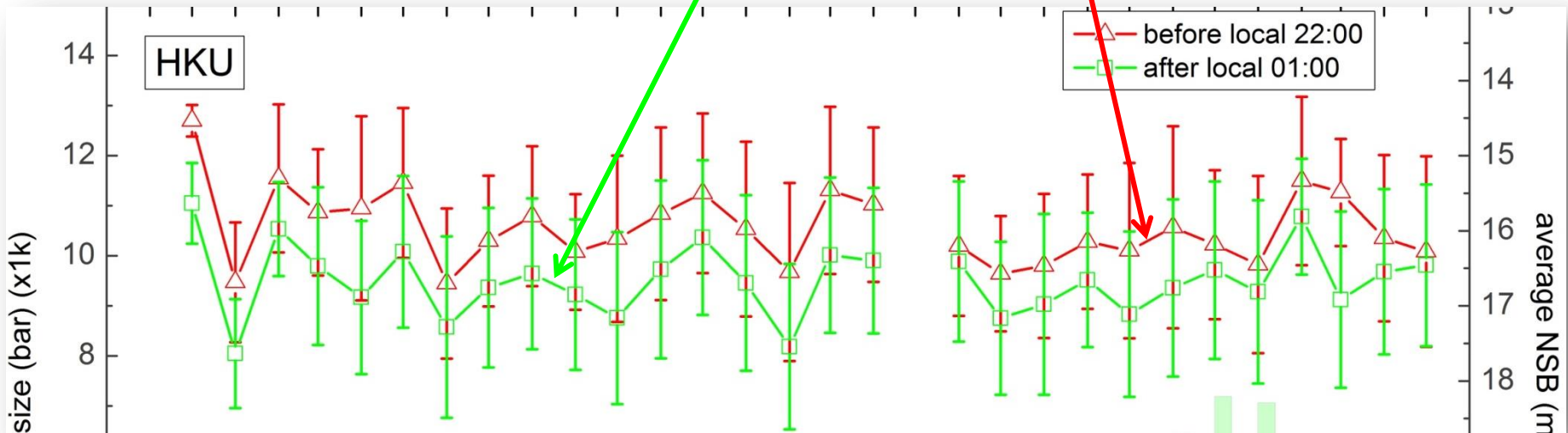
- ✓ Much darker NSB (land utilization and population density)
- ✓ Similar early and late NSB (minimal lighting usage)

Define parameter

$$\Delta\text{NSB}_{\text{late-early}} = \text{NSB}_{\text{late}} - \text{NSB}_{\text{early}}$$

Average NSB observed **after**
01:00 local time = NSB_{late}

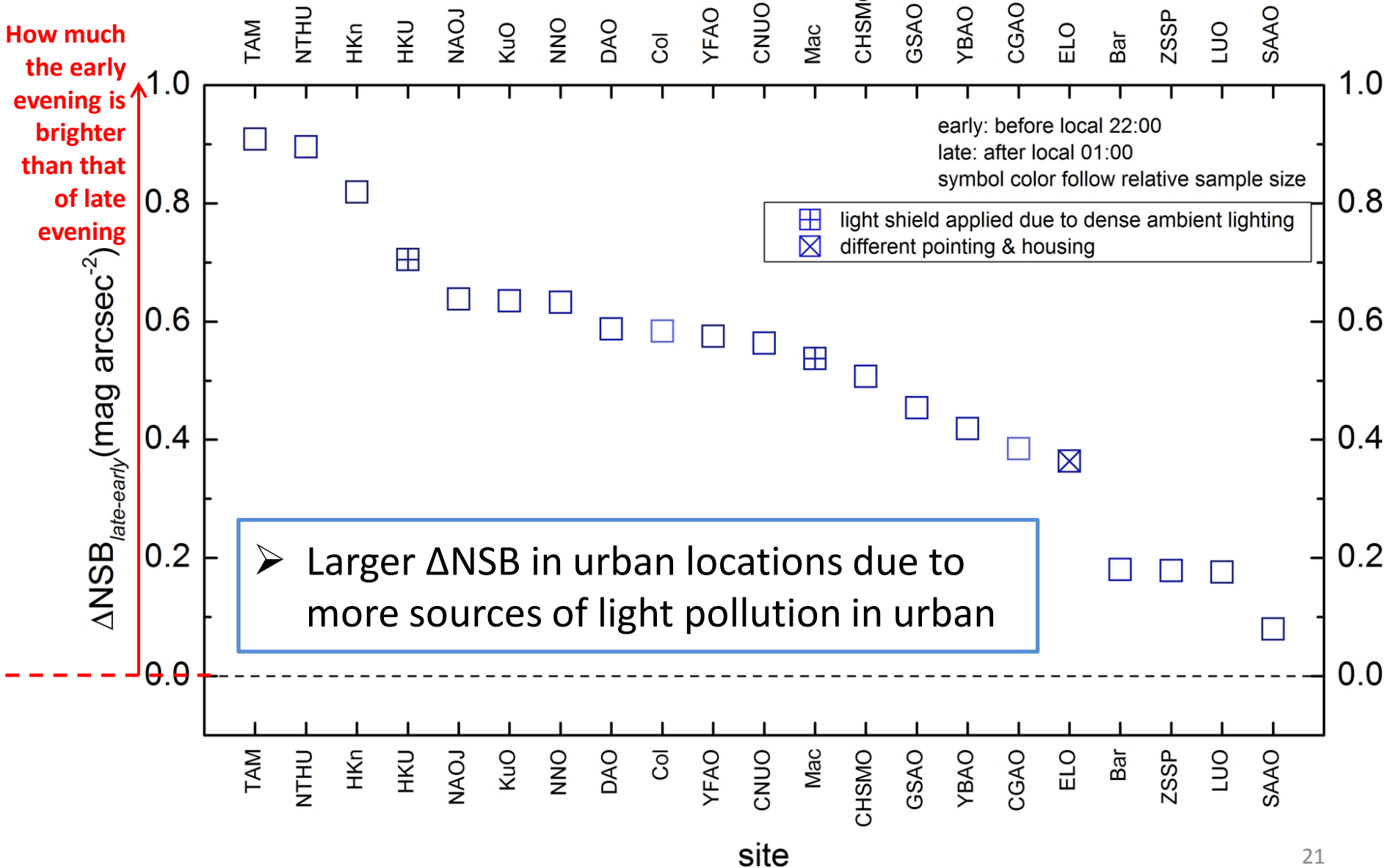
Average NSB observed **before**
22:00 local time = $\text{NSB}_{\text{early}}$



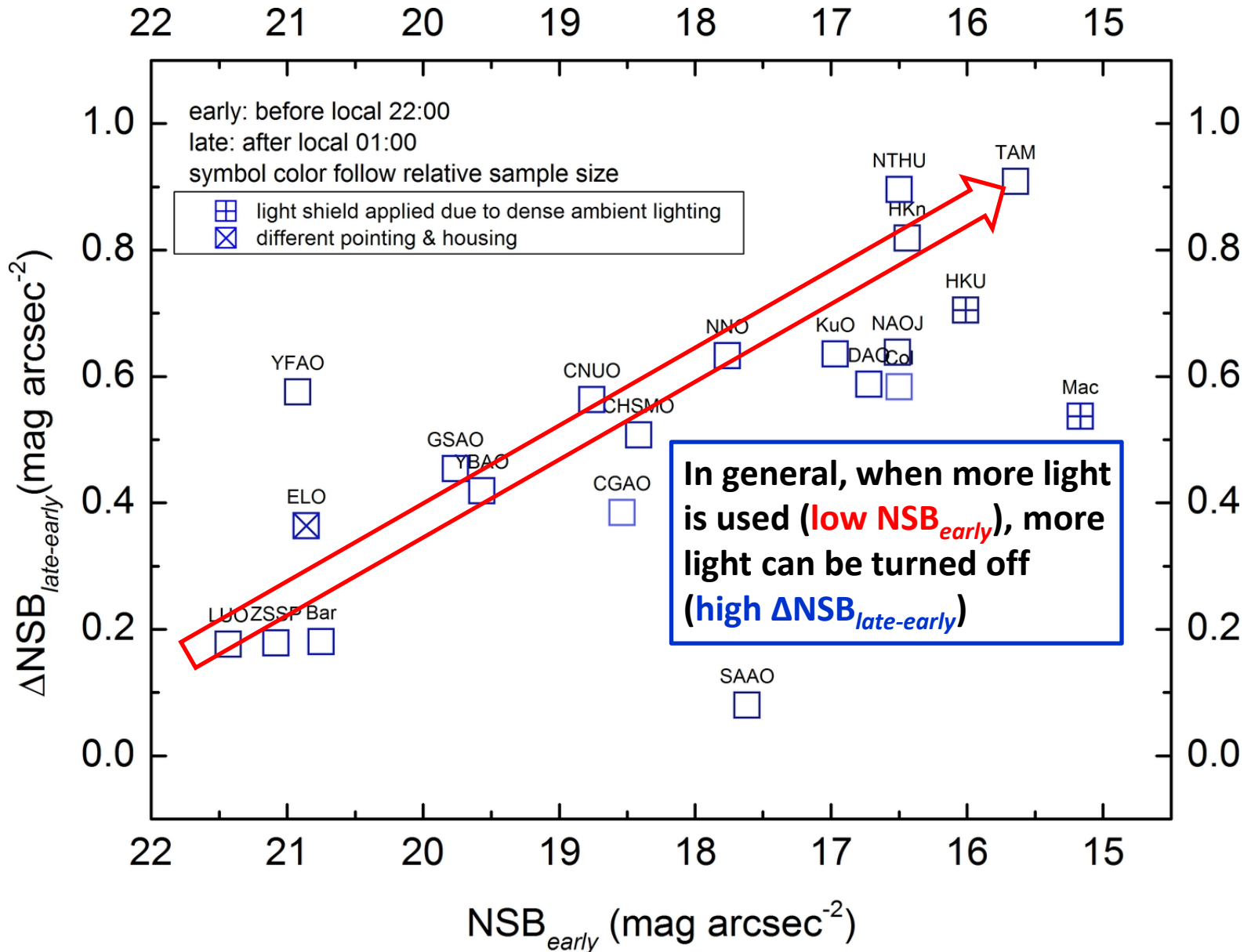
Positive $\Delta\text{NSB}_{\text{late-early}}$ \Rightarrow **darker** after mid-night

Negative $\Delta\text{NSB}_{\text{late-early}}$ \Rightarrow **brighter** after mid-night

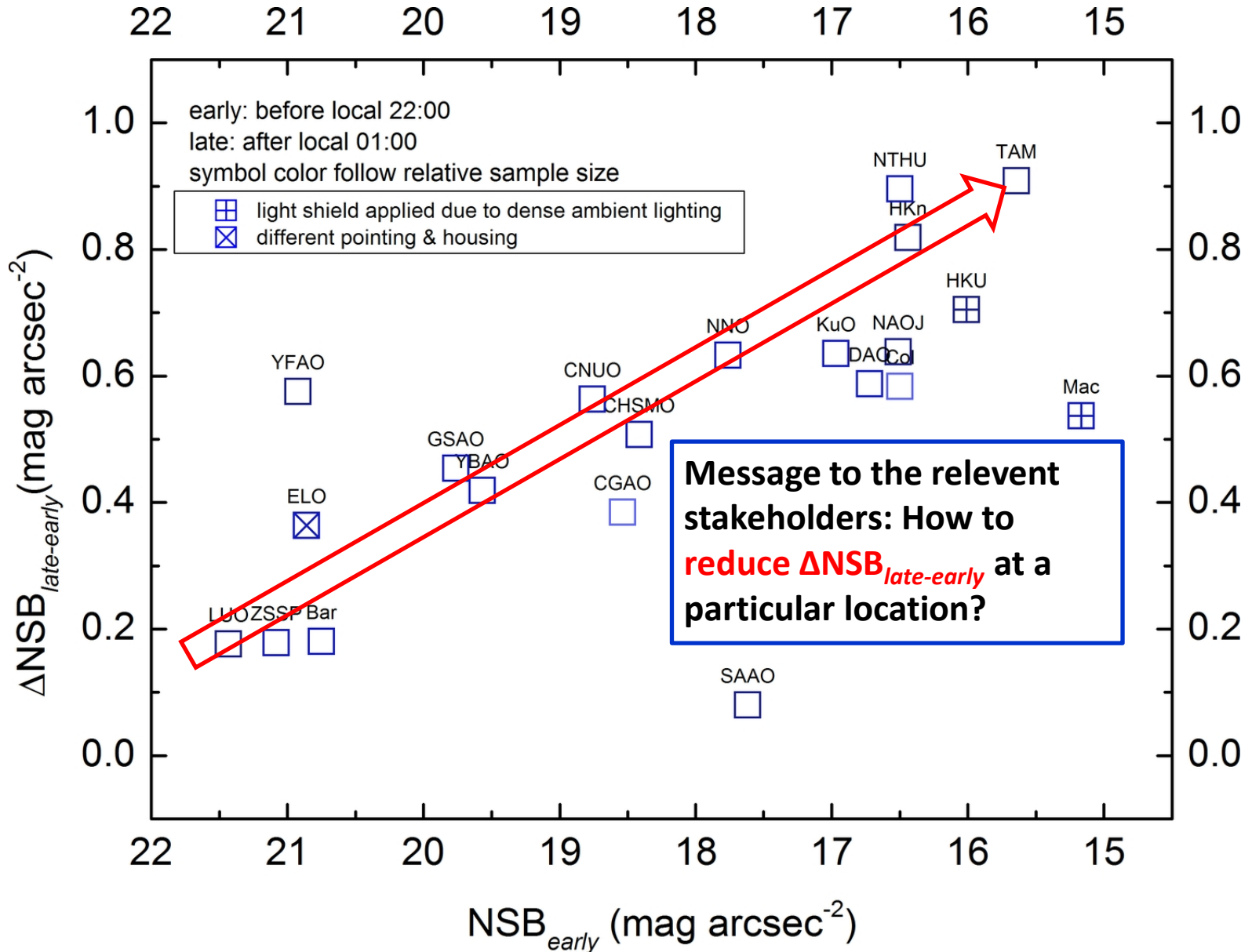
Average $\Delta\text{NSB}_{\text{late-early}}$ for each station



Average $\Delta\text{NSB}_{\text{late-early}}$ vs $\text{NSB}_{\text{early}}$ for each GaN-MN station

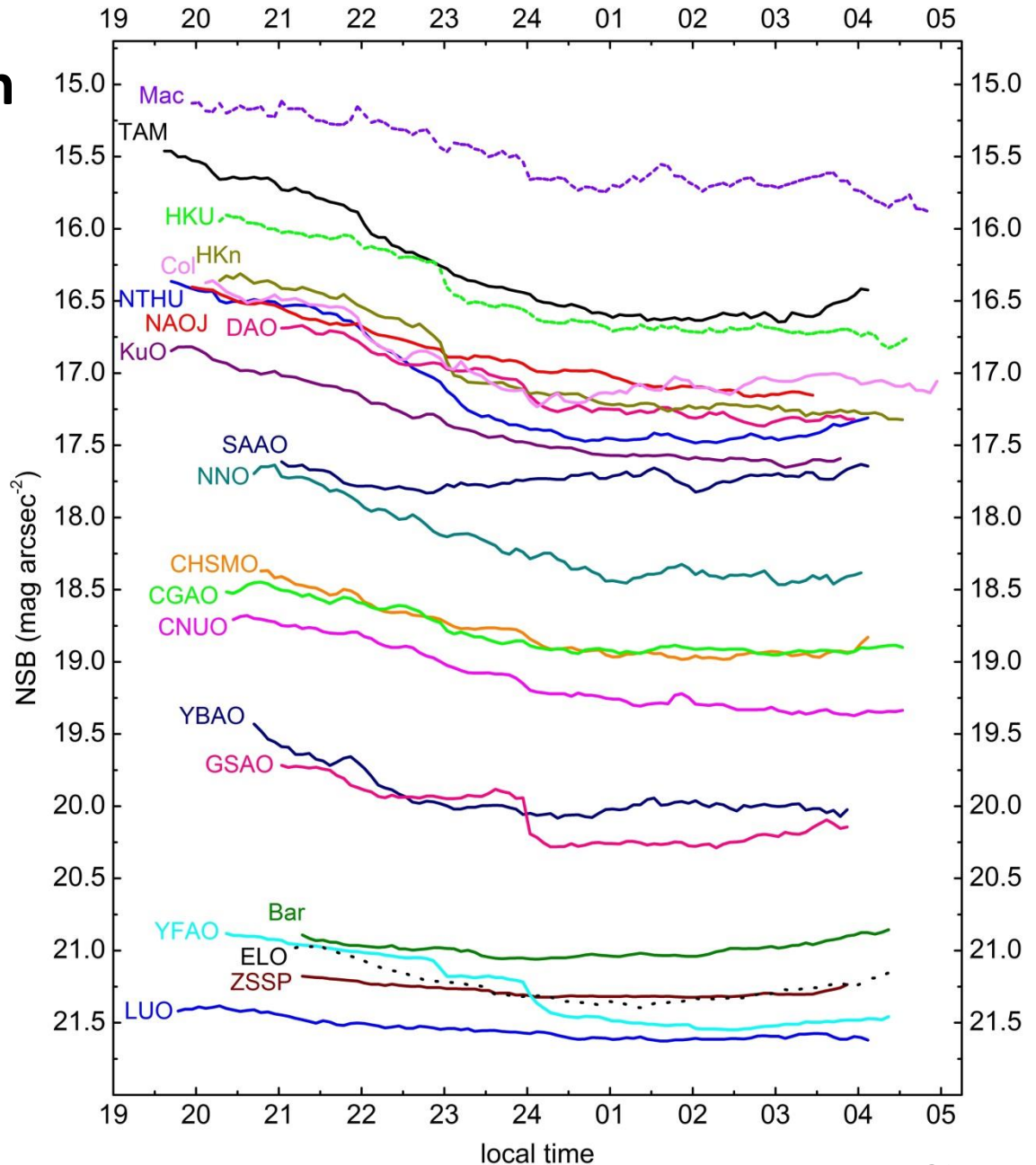


Average $\Delta\text{NSB}_{\text{late-early}}$ vs $\text{NSB}_{\text{early}}$ for each GaN-MN station



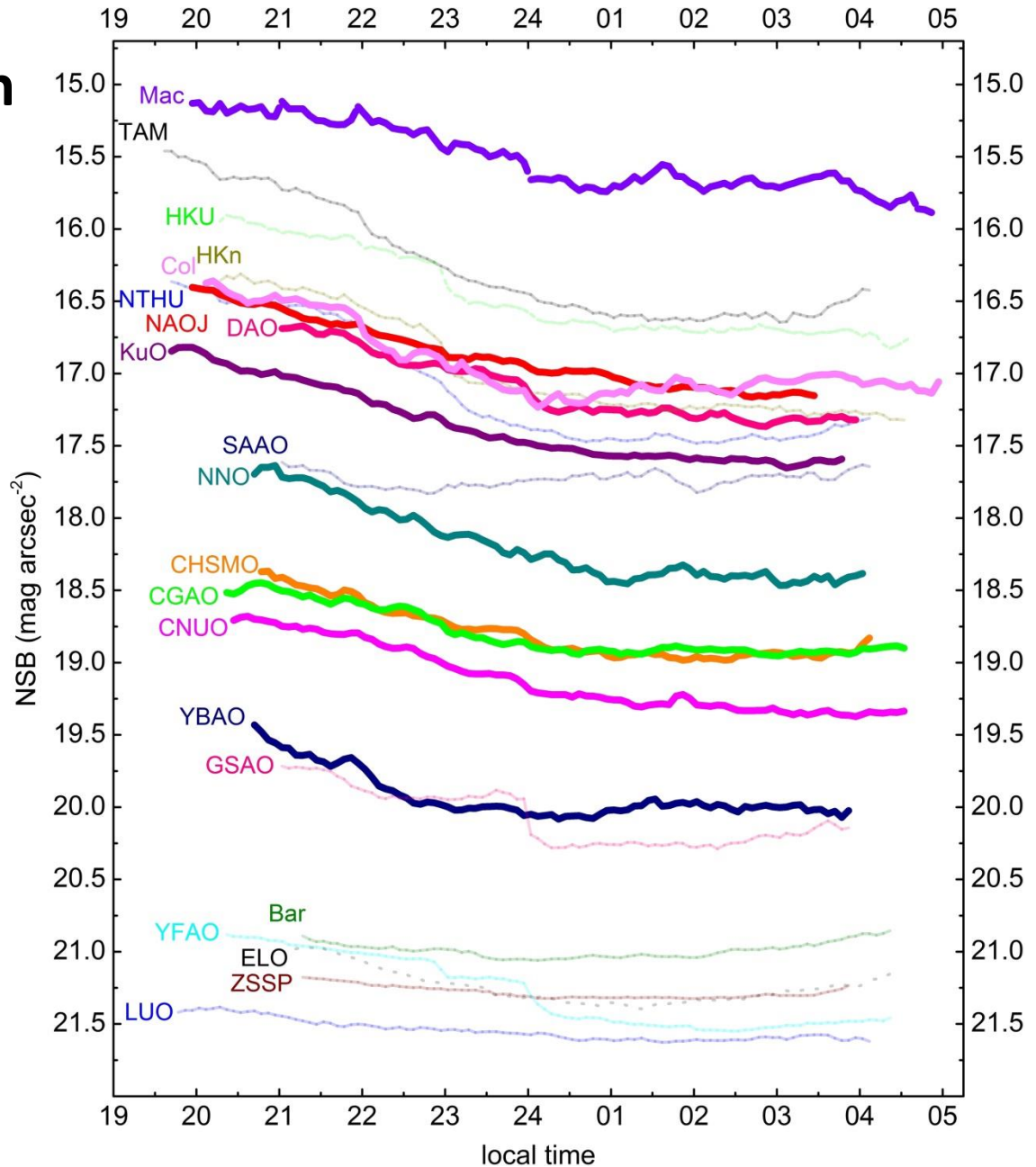
Average nightly variation of NSB for each station

- “Jellyfish scotograph” (introduced by Thomas Posch)
- Huge range of NSB among stations
- Different latitudes of stations lead to different sampling time (astro. dark durations)
- **Each curve is unique:** Depicts the outdoor lighting usage at that particular location



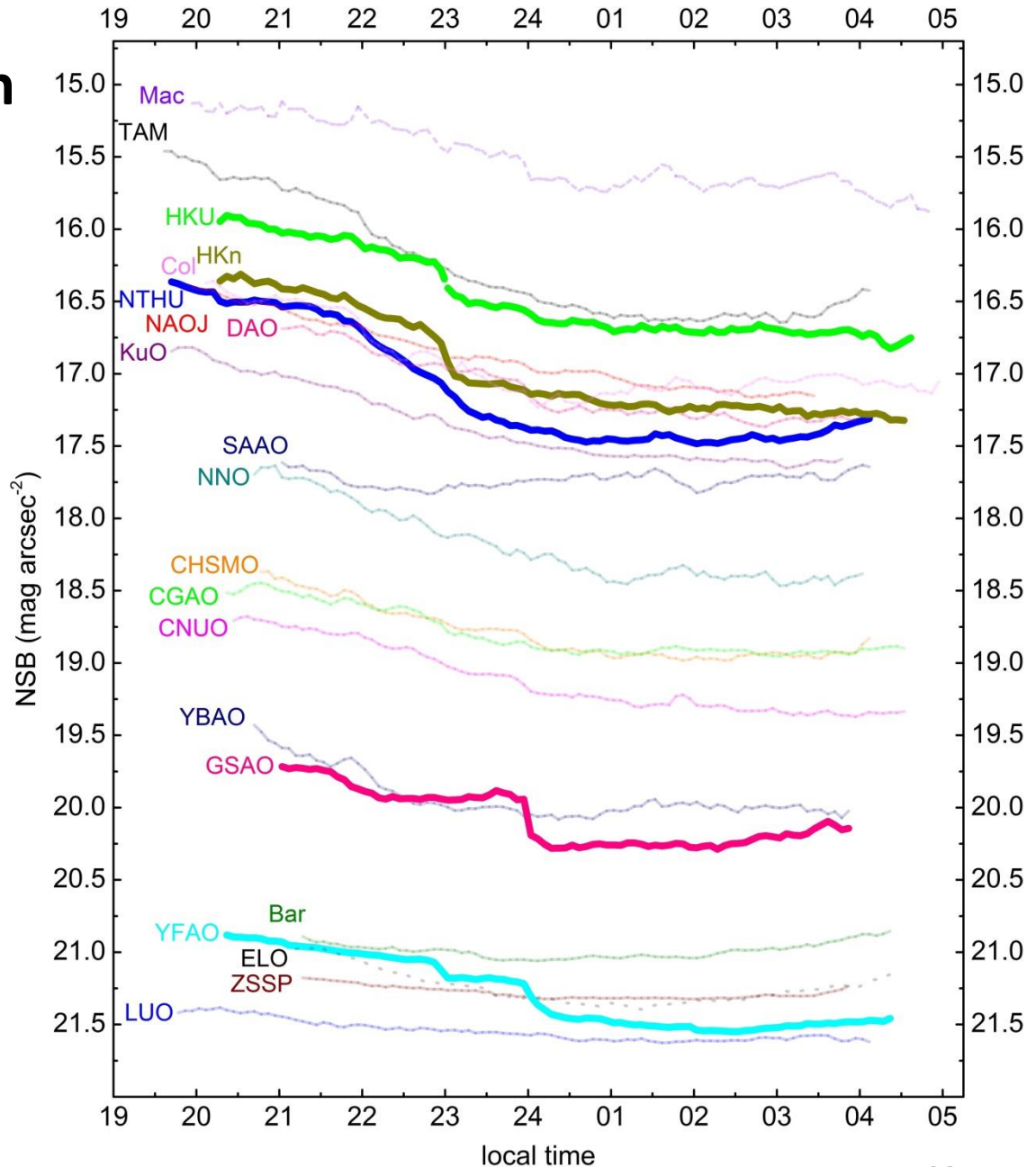
Average nightly variation of NSB for each station

- Most show a gradual decrease of sky brightness throughout the evening
- Suggest a decreasing amount of light pollution gradually due to reduction in light usage



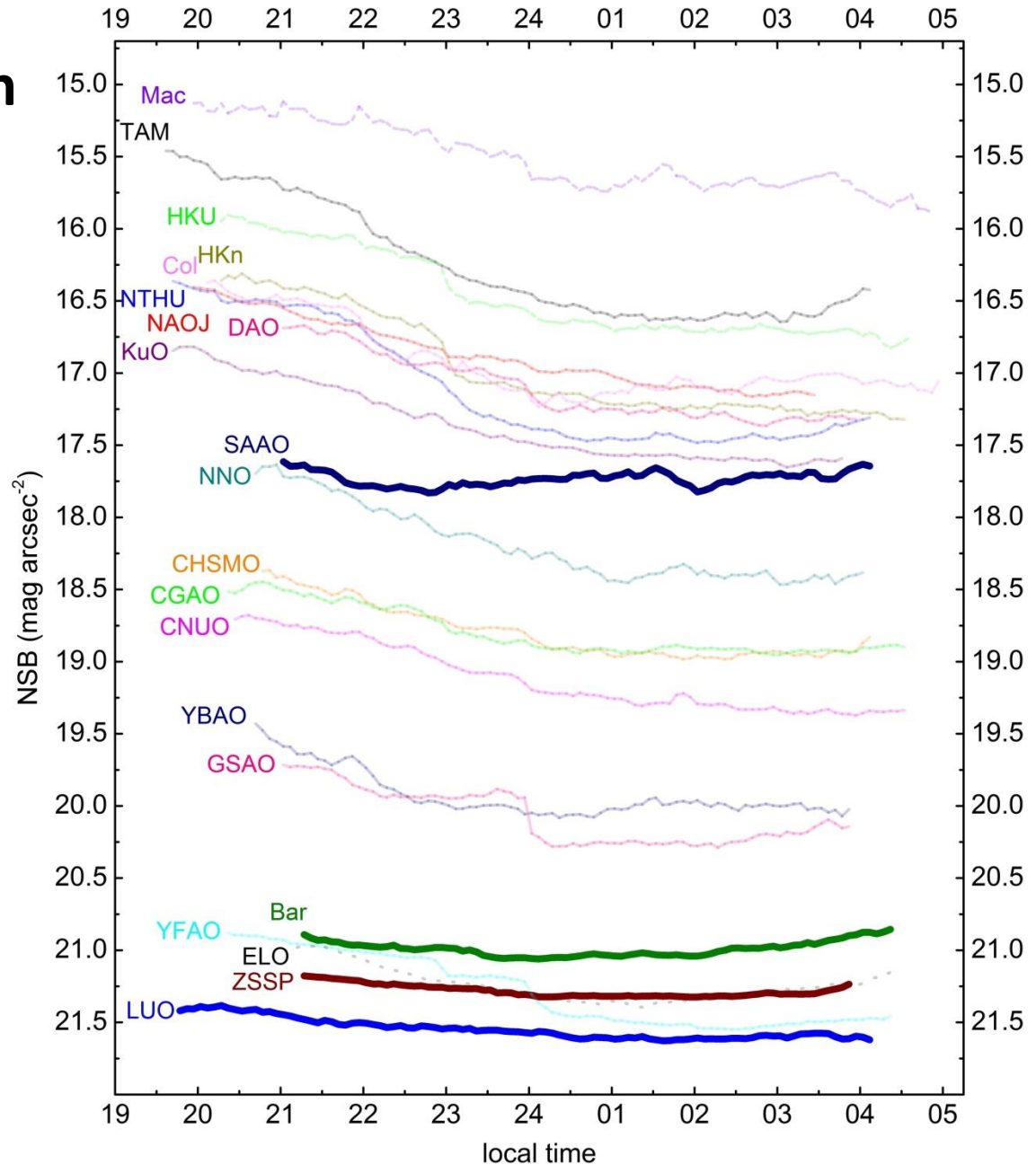
Average nightly variation of NSB for each station

- Some locations reveal one or multiple sharp drops (“curfews”) in sky brightness throughout the evening
- Lighting pattern identified: massive switch-off of lighting at specific times every night



Average nightly variation of NSB for each station

- Some locations have roughly steady level of sky brightness throughout the evening
- Two types identified:
 1. minimal ambient lighting
 2. special lighting usages



The Globe at Night - Sky Brightness Monitoring Network (GaN-MN)

- Easy to join in the effort
- All you need are:
 - A working SQM-LE with the standard Housing from Unihedron
 - Power supply and internet connection
- Benefits:
 - Present your results real-time to the world
 - Let's fight light pollution together!

Thank you!

For more information on the GaN-MN or willing to join,

1) Visit: <http://globeatnight-network.org/>

2) Email me (Chu Wing SO) at:

globeatnight.network@gmail.com or

gan-mn@qq.com

